Department of Veterans Affairs

JRRD

Volume 48, Number 9, 2011

Pages 1129–1136

Journal of Rehabilitation Research & Development

Increasing physical activity in multiple sclerosis: Replicating Internet intervention effects using objective and self-report outcomes

Deirdre Dlugonski, BS; Robert W. Motl, PhD;* Edward McAuley, PhD

Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL

Abstract—Our previous research indicated that an Internet intervention was effective in increasing self-reported physical activity in persons with multiple sclerosis (MS). The present study examined the efficacy of the same Internet intervention in persons with MS by using both objective and self-report measures of physical activity. Participants (N = 21) wore an accelerometer around the waist for 7 days and then completed the International Physical Activity Questionnaire (IPAQ) and Godin Leisure-Time Exercise Questionnaire (GLTEQ) before and after receiving the 12-week Internet intervention. The Internet intervention resulted in moderate increases in accelerometer activity counts (d = 0.68) and steps counts (d = 0.60), and this was paralleled by small increases in IPAQ (d = 0.43) and GLTEQ (d = 0.34) scores. The number of weeks that persons logged on was correlated with change in accelerometer activity counts (r = 0.42) and step counts (r = 0.37) but not change in IPAQ (r = 0.10) or GLTEQ (r = 0.08) scores. The novel contribution of this study was the observation that an Internet intervention was efficacious for increasing physical activity in persons with MS by using both objective and self-report measures.

Key words: accelerometer, inactive, Internet, intervention, multiple sclerosis, objective, physical activity, process evaluation, self-report, step count, walking.

INTRODUCTION

Physical activity has been associated with improvements in fatigue, spasticity, depression, quality of life, and walking mobility in persons with multiple sclerosis (MS) [1–4], and yet this population engages in substantially less physical activity than does the general population [5], who parenthetically are largely sedentary [6]. This underscores the importance of developing behavior change interventions for increasing physical activity in persons with MS. Ideally, such interventions should be based on theoretical principles that are supported by empirical research and delivered using a medium that matches the interest and usage profile of the target population. Evidence exists that constructs from social-cognitive theory [7] have been identified as determinants of physical activity in persons with MS [8–10] and, thereby, represent possible targets of a behavioral intervention. We further note that the Internet represents an appropriate means for the delivery of an intervention on the basis of the usage statistics and interests of those with MS [11].

We recently conducted a two-arm, randomized controlled trial (RCT) that tested the efficacy of a 12-week Internet intervention that was based on social-cognitive theory for increasing physical activity behavior in persons with MS [12]. The group that received the Internet

---

Abbreviations: EDSS = Expanded Disability Status Scale, GLTEQ = Godin Leisure-Time Exercise Questionnaire, IPAQ = International Physical Activity Questionnaire, MET = metabolic equivalent, MS = multiple sclerosis, PDDS = Patient-Determined Disease Steps, pdf = portable document format, RCT = randomized controlled trial.

***Address all correspondence to Robert W. Motl, PhD; Department of Kinesiology and Community Health, University of Illinois, 350 Freer Hall, Urbana, IL 61801; 217-265-0886; fax: 217-244-0702. Email: robmotl@illinois.edu**

DOI:10.1682/JRRD.2010.09.0192

intervention reported a statistically significant increase in physical activity over the 12-week period, whereas no significant change was reported by the wait-list control group. The major limitation of this pilot research was the reliance on a self-report measure of physical activity that might have reflected demand characteristics rather than an actual change in behavior. The present study examined the efficacy of the same Internet intervention for increasing physical activity in persons with MS by using both objective and self-report measures.

METHODS

Participants

We invited 24 persons with MS who were in the control group of the aforementioned two-arm RCT to be participants in a follow-up administration of the Internet intervention for increasing physical activity. One person was uninterested in participation, and two others did not provide subsequent physician's approval for participation in physical activity. This yielded a final sample of 21 persons with MS. All participants (1) had a definite diagnosis of MS consistent with McDonald criteria [13]; (2) had a relapsing-remitting MS clinical course consistent with Lublin and Reingold criteria [14]; (3) were independently ambulatory or ambulatory with single-point assistance (i.e., cane); (4) were relapse-free in the past 30 days; (5) had Internet access; (6) were willing to complete the questionnaires and wear an accelerometer; (7) were nonactive, defined as not engaging in regular physical activity (30 minutes accumulated each day) on more than 2 days of the week during the previous 6 months; (8) were free of contraindications for physical activity (e.g., no underlying cardiovascular disease); and (9) provided physician approval for beginning a physical activity program. There were neither inclusion nor exclusion criteria for usage of disease modifying agents or changes in medication status over the course of the intervention.

Measures

Physical Activity[*]

The ActiGraph model 7164 accelerometer (ActiGraph; Pensacola, Florida), Godin Leisure-Time Exercise Questionnaire (GLTEQ) [15], and short-form of the International Physical Activity Questionnaire (IPAQ) [16] served as the measures of physical activity in this study. The three measures were selected because evidence exists for the validity of their scores among persons with MS [17–19]. The ActiGraph model 7164 accelerometer consists of a single vertical-axis piezoelectric bender element, and this internal element generates an electrical signal proportional to the force acting on it. The electrical signal is digitized by an analog-to-digital converter and then numerically integrated over a specified interval. The integrated value of activity counts and/or step counts are retained in random access memory. The integrator is then reset. The accelerometer is initialized for a specific start time and sampling interval (i.e., epoch), and data are taken from the unit for analysis with use of a docking station connected to a personal computer equipped with ActiGraph software. The data are then entered into Microsoft Excel (Microsoft; Redmond, Washington) for processing of daily activity and/or step counts. The sampling epoch in this study was 1 minute, and the accelerometers were worn on an elastic belt around the waist on a location above the nondominant hip during the waking hours for a 7-day period. Waking hours was operationally defined as the moment of getting out of bed in the morning until the moment of getting into bed in the evening, but excluded periods of showering, bathing, and swimming. Using a log, the participants recorded the time that the accelerometer was worn daily, and this log was visually verified during processing of the minute-by-minute accelerometer data. We summed the minute-by-minute activity counts and step counts for each of the 7 days and then averaged the total daily activity counts and step counts across the 7-day period. This provided accelerometer data in metrics of both total activity counts each day and total step counts each day.

The GLTEQ [15] is self-administered measure of usual physical activity, and although it contains two-parts, we only included the first part in this study on the basis of previous research [17–18]. The first part of the GLTEQ has three items. The items measure the frequency of strenuous (e.g., running, jogging, vigorous swimming), moderate

[*]Descriptions of the physical activity measures parallel those previously published in Motl RW, McAuley E, Wynn D, Suh Y, Weikert M, Dlugonski D. Symptoms and physical activity among adults with relapsing-remitting multiple sclerosis. J Nerv Ment Dis. 2010;198(3):219–19. [PMID: 20215999] DOI:10.1097/NMD.0b013e3181d14131 and Weikert M, Motl RW, Suh Y, McAuley E, Wynn D. Accelerometry in persons with multiple sclerosis: Measurement of physical activity or walking mobility? J Neurol Sci. 2010;290(1–2):6–11. [PMID: 20060544] DOI:10.1016/j.jns.2009.12.021.

(e.g., fast walking, easy bicycling, easy swimming), and mild (e.g., yoga, easy walking) exercises that are performed for periods of 15 or more minutes during one's leisure time over a usual week [15]. The reported weekly frequencies of strenuous, moderate, and mild activities are then multiplied by 9, 5, and 3 metabolic equivalents (METs), respectively, and further summated into a measure of total leisure activity. GLTEQ scores can range between 0 and 119.

The short-form of the IPAQ contains six items [16]. Those items measure the frequency and duration of vigorous-intensity activities (i.e., those that take hard physical effort and make you breath much harder than normal), moderate-intensity activities (i.e., those that take moderate physical effort and make you breath somewhat harder than normal), and walking during a 7-day period [16]. We did not include the duration component of the IPAQ. This is because previous research has identified problems with the accuracy of recall of physical activity duration among persons with MS [17]. The frequency values reported for vigorous, moderate, and walking activities were multiplied by 8.0, 4.0, and 3.3 METs, respectively, and then summated into a continuous measure of physical activity with scores ranging between 0 and 107.

Disease Severity[*]

Neurological disability was measured with the Patient-Determined Disease Steps (PDDS) scale [20]. The PDDS scale contains a single item for measuring self-reported neurological impairment. This item is rated on an ordinal level scale ranging from 0 ("normal") to 8 ("bedridden"). The PDDS scale was developed to be an inexpensive surrogate for the Expanded Disability Status Scale (EDSS). The scores from the PDDS are strongly and linearly correlated with scores from a physician-administered EDSS (r = 0.93) [20]. This scale was included only for describing the disease severity of the sample in the present study.

Process Evaluation

Participants completed a questionnaire regarding overall satisfaction with the program, Web site, and staff on a scale with anchors of 1 ("completely unsatisfied") and 5 ("completely satisfied"). We further asked participants to indicate whether they would recommend the program to others with MS on a scale with anchors of 1 ("strongly disagree") and 5 ("strongly agree"). All questions were followed with open space for the provision of additional feedback.

Intervention

The structure and content of the Web site for the Internet intervention were initially developed in our previous RCT that was associated with an increase in self-reported physical activity in persons with MS. We further note that our approach included important components of Internet interventions, including use of a theoretical framework, multimedia content, and provision of telephone and email support for the Web site [21–22]. The primary content of the Internet intervention was based on social cognitive theory and represented the transformation of an effective face-to-face intervention that increased adherence with prescribed exercise training in persons with MS [23]. The content was provided as text supplemented by video and portable document format (pdf) files (i.e., multimedia) and focused on the four principle elements of social cognitive theory (i.e., self-efficacy, outcome expectations, impediments, and goal setting). This yielded 4 modules (Getting Started, Planning for Success, Beating the Odds, and Sticking with It) and 10 chapters for the intervention. The Getting Started module included chapters on the benefits of physical activity for persons with MS, instructions for self-monitoring with an OMRON pocket pedometer (HJ-720ITC, OMRON Corporation; Kyoto, Japan), and instructions for becoming more physically active. The Planning for Success module included chapters on goal setting and feedback, outcome expectations, and self-efficacy. The Beating the Odds module included chapters on barriers, strategies for overcoming barriers, and social support. The Sticking with It module included a chapter on maintaining an active lifestyle and exercise relapse prevention. The supplementary video files were of persons with MS discussing physical activity behavior and associated experiences with becoming more physically active. The supplementary pdf files were of research articles for documenting the statements within the modules, a manual on incorporating physical activity in everyday life, and worksheets and questionnaires for further developing the personal relevance of the content. Additionally, we conducted online group chat sessions twice a week, included an ongoing participant forum for discussions of physical activity behavior change, and provided a toll-free telephone line and a study email address for supporting the Web site.

[*]The description of the PDDS parallels that previously published in Weikert M, Motl RW, Suh Y, McAuley E, Wynn D. Accelerometry in persons with multiple sclerosis: Measurement of physical activity or walking mobility? J Neurol Sci. 2010;290(1–2):6–11. [PMID: 20060544] DOI:10.1016/j.jns.2009.12.021.

This was further supported by automated email announcements about new information, updates, and changes on the Web site. The intervention materials were delivered in a titrated fashion such that chapters were made "accessible" weekly for the first month, biweekly for the second month, and once in the third month.

Procedure

The participants wore an accelerometer for 7 days and then completed the PDDS, GLTEQ, and IPAQ before and after receiving the 12-week Internet intervention. These materials were sent and returned through the U.S. Postal Service in postage-paid envelopes. Participants were paid $10 for each completed packet.

Data Analysis

Any missing data for the follow-up assessment were replaced with the participant's baseline value, thereby allowing for an intent-to-treat analysis. The data analysis itself was performed with use of SPSS version 17.0 (SPSS Inc; Chicago, Illinois). Descriptive statistics are presented in the **Table** and the text as mean ± standard deviation. We used paired-samples *t*-tests with a one-tailed test for comparing changes in means from pre- to postintervention for accelerometer activity counts and step counts and GLTEQ and IPAQ scores. Effect sizes for mean differences were expressed as Cohen's *d* (difference in means divided by the standard deviation of the difference) and interpreted as small, moderate, or large based on values of 0.2, 0.5, and 0.8, respectively. We further examined the relationship among the four measures of physical activity and Web site log on activity by using Pearson product-moment correlations (*r*) and a one-tailed test of significance.

Table.

Descriptive statistics (mean ± standard deviation) for physical activity measures pre- and postintervention in sample of 21 persons with multiple sclerosis.

Measure	Preintervention	Postintervention
Activity Counts (counts/d)	168,974 ± 70,669	213,943 ± 85,155
Step Counts (steps/d)	6,435 ± 2,512	7,822 ± 2,943
GLTEQ	13.9 ± 13.1	20.1 ± 21.1
IPAQ	16.4 ± 10.7	20.2 ± 11.7

GLTEQ = Godin Leisure-Time Exercise Questionnaire, IPAQ = International Physical Activity Questionnaire.

RESULTS

Sample Characteristics

The participants ($N = 21$) were mostly female ($n = 19$) and Caucasian ($n = 19$), with a mean age of 46.4 ± 8.1 years. All participants had a definite diagnosis of MS, with a mean duration of 7.8 ± 6.6 years. The median PDDS score of 1.0 (range = 0–5) reflects that the sample was independently ambulatory with mild disability characterized by noticeable symptoms and a small effect on lifestyle.

Missing Data

Two people withdrew from the study and did not provide follow-up data. Two additional persons did not have usable accelerometer data because of either unit error or only 1 day of valid data. We replaced those missing follow-up data with the corresponding baseline value.

Physical Activity Outcomes

The descriptive statistics for the four physical activity measures are provided in the **Table**. The paired-samples *t*-tests indicated statistically significant improvements from pre- to postintervention for accelerometer activity counts ($t(20) = 3.14$, $p = 0.002$) and step counts ($t(20) = 2.77$, $p = 0.006$); those effects remained unchanged in a completer analysis using only available data rather than replacing the missing value. The paired-samples *t*-tests further indicated a statistically significant improvement in IPAQ scores ($t(20) = 1.97$, $p = 0.03$) and an effect that approached significance for GLTEQ scores ($t(20) = 1.57$, $p = 0.07$); those effects again remained unchanged in a completer analysis. The effect sizes for changes in accelerometer activity counts, accelerometer step counts, IPAQ scores, and GLTEQ scores were 0.68, 0.60, 0.43, and 0.34, respectively. The effects were moderate in magnitude for the objective measures of physical activity and small for the self-report measures of physical activity.

Web Site Usage

The percentage of persons who logged on each week was the highest in weeks 1 (76%) and 2 (81%). The percentage of persons who logged on each week declined over the 12-week intervention period such that it was the lowest (52%) in weeks 10, 11, and 12. The average percentage of persons who logged on each week was 63 ± 36 percent over the 12-week period. One person never logged on, whereas six persons logged on every week over the 12-week period. On average, the participants logged on 7.5 ± 4.3 of the weeks over the 12-week period.

Log-Ins as Correlates of Intervention Success

The number of weeks that persons logged on was significantly correlated with change (post minus pre) in accelerometer activity counts ($r = 0.42$, $p = 0.03$) and step counts ($r = 0.37$, $p = 0.05$), but not change in IPAQ ($r = 0.10$, $p = 0.32$) or GLTEQ ($r = 0.08$, $p = 0.36$) scores. Those who logged on more times over the 12-week period had a larger increase in objective measures of physical activity.

Process Evaluation

There was a modest response rate for the process evaluation ($n = 12$ or 57% of the participants). A high degree of satisfaction was found for the Internet intervention (mean = 4.7 ± 0.6, range = 3–5) and staff (mean = 4.7 ± 0.5, range = 4–5), but neutral satisfaction for the Web site itself (mean = 3.6 ± 0.9, range = 2–5). Open-ended questions indicated that the neutral satisfaction for the Web site was largely directed toward the online group chat sessions and forums. Overall, participants indicated a strong willingness to recommend the program to others with MS (mean = 4.5 ± 0.8, range = 3–5).

DISCUSSION

The novel contribution of the present study was the observation that an Internet intervention was associated with an increase in both objective and self-report measures of physical activity in persons with MS. This extends our previous research that only included a self-report measure of physical activity for documenting the efficacy of the Internet intervention [12]. Collectively, the two studies indicate that an appropriately designed behavioral intervention that targets variables based on both social cognitive theory and empirical research and is delivered through the Internet can successfully increase physical activity behavior in persons with MS. Such an observation is critical and timely because persons with MS are largely sedentary and engage in less physical activity than the general population [5]. If we can successfully increase the level of physical activity in persons with MS, this population might improve in other secondary outcomes, such as fatigue, spasticity, depression, mobility, and quality of life [1,3–4,24]. To that end, the Internet intervention that successfully increased physical activity in the present study and previous research [12] should be administered in a larger RCT that examines the possible secondary effects of increased physical activity on meaningful outcomes for persons with MS.

This study quantified the efficacy of the Internet intervention for increasing physical activity by using both objective and self-report measures. Interestingly, statistically significant and moderate increases in the objective measures of physical activity were observed, whereas only a significant increase in one of the self-report measures was seen and the changes on both self-report measures were small in magnitude. One explanation for the differential effect of the Internet intervention based on the type of outcome measure might be the emphasis that was placed on walking and lifestyle physical activity, instead of structured exercise, on the intervention Web site and through use of a pedometer. These types of physical activity might occur in brief and more sporadic bouts throughout one's day and, by extension, might be more difficult to quantify with a self-report measure of physical activity [25].

Another interesting result of the present study was demonstrated in the analysis of the association between log-in activity and change in physical activity behavior. The change in objectively measured physical activity was more strongly correlated with the number of log-ins over the 12-week period than was the change in self-reported physical activity. The lack of an association between log-ins and self-reported change in physical activity is consistent with our previous study that examined the efficacy of the Internet intervention in persons with MS [12]. This pattern of findings might suggest that the Internet intervention itself is associated with a change in physical activity rather than simply demand characteristics or recall biases that might be reflected in self-report surveys. If the improvement in physical activity was simply a result of those threats to internal validity, then there would likely be stronger associations between self-reported physical activity and log-ins than for objective measures of physical activity and log-ins. This was not the case in the present study.

We conducted a process evaluation for generating feedback regarding the perceptions of the Internet intervention and this, too, extends our previous research. Such feedback is important for informing decisions on possible alterations of the Internet intervention for subsequent evaluations. Although only 12 of the 21 participants provided feedback, those who completed the process evaluation were generally satisfied and would recommend this program to other persons with MS. Interestingly, the participants provided neutral ratings of the Web site itself and this was largely associated with disinterest in the online group chat sessions and forums. Regarding the chat sessions, one participant described the experience as "schizophrenic" and providing minimal personally relevant information for changing physical activity behavior. We believe that this component of the Internet intervention should be modified in subsequent studies, perhaps by providing one-on-one chat sessions with an interventionist via either video or telephone conferencing. Such an approach might further enhance log-in activity for the Web site itself, and this is critical because the log-in rates declined over the course of the 12-week intervention.

The inclusion of an objective measure of physical activity and the formative analysis are improvements over our previous research, but the present study does have significant limitations. Two notable limitations are the small sample size and the lack of any true control or comparison group. These limit the generalizability of our findings and the assessment of the intervention efficacy. An additional limitation is that we did not record usage of disease-modifying medications nor did we require that participants not change such medications over the course of the intervention. To that end, the observed changes in physical activity might reflect initiation of a new medication such as Fampridine-SR, an agent with beneficial effects on ambulation [26], rather than the intervention itself. We further did not include measures of secondary outcomes and do not have evidence that the increase in physical activity associated with the Internet intervention translates into beneficial effects on outcomes such as fatigue, depression, cognition, mobility, and quality of life.

CONCLUSIONS

Collectively, the present study confirms and extends findings from our previous research demonstrating the efficacy of a 12-week Internet intervention for increasing physical activity in persons with MS [12]. The present study provided (1) evidence for an increase in physical activity by using both objective and self-report measures and (2) feedback through a process evaluation for improving the Internet intervention in subsequent administrations. To that end, we believe that an appropriately designed behavioral intervention that targets variables based on both social cognitive theory and empirical research and delivered through the Internet can successfully increase physical activity behavior in persons with MS and might have additional effects on secondary outcomes.

ACKNOWLEDGMENTS

Author Contributions:
Study concept and design: D. Dlugonski, R. W. Motl, E. McAuley.
Acquisition of data: D. Dlugonski.
Analysis and interpretation of data: D. Dlugonski, R. W. Motl.
Drafting of manuscript: D. Dlugonski.
Critical revision of manuscript for important intellectual content: R. W. Motl, E. McAuley.
Statistical analysis: R. W. Motl.
Financial Disclosures: The authors have declared that no competing interests exist.
Funding/Support: This material was unfunded at the time of manuscript preparation.
Institutional Review: The procedures were reviewed and approved by an institutional review board, and all participants provided written informed consent.
Participant Follow-Up: The authors plan to inform participants of the publication of this study.

REFERENCES

1. Coote S, Garrett M, Hogan N, Larkin A, Saunders J. Getting the balance right: A randomised controlled trial of physiotherapy and exercise interventions for ambulatory people with multiple sclerosis. BMC Neurol. 2009;9:34. [PMID: 19607666] DOI:10.1186/1471-2377-9-34
2. Motl RW, Gosney JL. Effect of exercise training on quality of life in multiple sclerosis: A meta-analysis. Mult Scler. 2008;14(1):129–35. [PMID: 17881388] DOI:10.1177/1352458507080464
3. Rietberg MB, Brooks D, Uitdehaag DM, Kwakkel G. Exercise therapy for multiple sclerosis. Cochrane Database Syst Rev. 2005;(1):CD003980. [PMID: 15674920]
4. Snook EM, Motl RW. Effect of exercise training on walking mobility in multiple sclerosis: A meta-analysis. Neurorehabil Neural Repair. 2009;23(2):108–16. [PMID: 18948413] DOI:10.1177/1545968308320641
5. Motl RW, McAuley E, Snook EM. Physical activity and multiple sclerosis: A meta-analysis. Mult Scler. 2005;11(4): 459–63. [PMID: 16042230] DOI:10.1191/1352458505ms1188oa
6. Centers for Disease Control and Prevention (CDC). Prevalence of no leisure-time physical activity—35 states and the District of Columbia, 1988–2002. MMWR Morb Mortal Wkly Rep. 2004;53(4):82–86. [PMID: 14762333]
7. Bandura A. Health promotion by social cognitive means. Health Educ Behav. 2004;31(2):143–64. [PMID: 15090118] DOI:10.1177/1090198104263660
8. Motl RW, McAuley E, Doerksen S, Hu L, Morris KS. Preliminary evidence that self-efficacy predicts physical activity

in multiple sclerosis. Int J Rehabil Res. 2009;32(3): 260–63. [PMID: 19685577] DOI:10.1097/MRR.0b013e328325a5ed

9. Motl RW, Snook EM, McAuley E, Scott JA, Douglass ML. Correlates of physical activity among individuals with multiple sclerosis. Ann Behav Med. 2006;32(2):154–61. [PMID: 16972813] DOI:10.1207/s15324796abm3202_13
10. Suh Y, Weikert M, Dlugonski D, Sandroff B, Motl RW. Social cognitive correlates of physical activity: Findings from a cross-sectional study of adults with relapsing-remitting multiple sclerosis. J Phys Act Health. 2011;8(5):626–35. [PMID: 21734307]
11. Wardell L, Hum S, Laizner AM, Lapierre Y. Multiple sclerosis patients' interest in and likelihood of using online health-care services. Int J MS Care. 2009;11:79–89.
12. Motl RW, Dlugonski D, Wójcicki TR, McAuley E, Mohr DC. Internet intervention for increasing physical activity in persons with multiple sclerosis. Mult Scler. 2011;17(1): 116–28. [PMID: 20921239] DOI:10.1177/1352458510383148
13. Polman CH, Reingold SC, Edan G, Filippi M, Hartung HP, Kappos L, Lublin FD, Metz LM, McFarland HF, O'Conner PW, Sandberg-Wollheim M, Thompson AJ, Weinshenker BG, Wolinsky JS. Diagnostic criteria for multiple sclerosis: 2005 revisions to the "McDonald Criteria." Ann Neurol. 2005;58(6):840–46. [PMID: 16283615] DOI:10.1002/ana.20703
14. Lublin FD, Reingold SC. Defining the clinical course of multiple sclerosis: Results of an international survey. National Multiple Sclerosis Society (USA) Advisory Committee on Clinical Trials of New Agents in Multiple Sclerosis. Neurology. 1996;46(4):907–11. [PMID: 8780061]
15. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. Can J Appl Sport Sci. 1985; 10(3):141–46. [PMID: 4053261]
16. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P. International Physical Activity Questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35(8):1381–95. [PMID: 12900694] DOI:10.1249/01.MSS.0000078924.61453.FB
17. Gosney JL, Scott JA, Snook EM, Motl RW. Physical activity and multiple sclerosis: Validity of self-report and objective measures. Fam Community Health. 2007;30(2):144–50. [PMID: 19241650]
18. Motl RW, McAuley E, Snook EM, Scott JA. Validity of physical activity measures in ambulatory individuals with multiple sclerosis. Disabil Rehabil. 2006;28(18):1151–56. [PMID: 16966236] DOI:10.1080/09638280600551476
19. Snook EM, Motl RW, Gliottoni RC. The effect of walking mobility on the measurement of physical activity using accelerometry in multiple sclerosis. Clin Rehabil. 2009; 23(3):248–58. [PMID: 19218299] DOI:10.1177/0269215508101757
20. Hadjimichael O, Kerns RD, Rizzo MA, Cutter G, Vollmer T. Persistent pain and uncomfortable sensations in persons with multiple sclerosis. Pain. 2007;127(1–2):35–41. [PMID: 16949751] DOI:10.1016/j.pain.2006.07.015
21. Ritterband LM, Thorndike FP, Cox DJ, Kovatchev BP, Gonder-Frederick LA. A behavior change model for Internet interventions. Ann Behav Med. 2009;38(1):18–27. [PMID: 19802647] DOI:10.1007/s12160-009-9133-4
22. Barak A, Klein B, Proudfoot JG. Defining Internet-supported therapeutic interventions. Ann Behav Med. 2009;38(1): 4–17. [PMID: 19787305] DOI:10.1007/s12160-009-9130-7
23. McAuley E, Motl RW, Morris KS, Hu L, Doerksen SE, Elavsky S, Konopack JF. Enhancing physical activity adherence and well-being in multiple sclerosis: A randomised controlled trial. Mult Scler. 2007;13(5):652–59. [PMID: 17548446] DOI:10.1177/1352458506072188
24. Motl RW, Snook EM. Physical activity, self-efficacy, and quality of life in multiple sclerosis. Ann Behav Med. 2008; 35(1):111–15. [PMID: 18347911]
25. Tudor-Locke CE, Myers AM. Challenges and opportunities for measuring physical activity in sedentary adults. Sports Med. 2001;31(2):91–100. [PMID: 11227981] DOI:10.2165/00007256-200131020-00002
26. Goodman AD, Brown TR, Edwards KR, Krupp LB, Schapiro RT, Cohen R, Marinucci LN, Blight AR; MSF204 Investigators. A phase 3 trial of extended release oral dalfampridine in multiple sclerosis. Ann Neurol. 2010;68(4): 494–502. [PMID: 20976768] DOI:10.1002/ana.22240

Submitted for publication September 30, 2010. Accepted in revised form March 8, 2011.

This article and any supplementary material should be cited as follows:
Dlugonski D, Motl RW, McAuley E. Increasing physical activity in multiple sclerosis: Replicating Internet intervention effects using objective and self-report outcomes. J Rehabil Res Dev. 2011;48(9):1129–36.
DOI:10.1682/JRRD.2010.09.0192